NATURAL RESOURCE INVENTORY AND MONITORING GUIDELINES #33

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1.0 **DIRECTOR'S STATEMENT**

The principle purpose of the North Carolina State Parks System has been, and will continue to be, to establish and maintain refuges where all of the components and processes of high quality natural ecosystems can be preserved. Fulfillment of this charge is a demanding duty, and a duty that has little prospect of becoming anything but more difficult. The isolation of parks by encroaching development, biogeochemical changes from acid deposition and airborne pollutants, exotic species invasions, and global climate change, are examples of significant threats to our parks' natural resources.

To advance as able stewards we must become more knowledgeable of the identity and condition of the many species and natural communities present in the parks. Implementation of an organized natural resource inventory and monitoring program is the most viable means to this objective. Once we learn what we have, where it is, and how it is vulnerable, we will better recognize threats to our resources and more effectively respond to them with management actions.

The following Natural Resource Inventory and Monitoring Guidelines provide a methodical procedure for establishing effective inventory and monitoring programs in all park units. The initiation of natural resource inventory and monitoring programs in N.C. state parks will follow the direction of these guidelines.

Sincerely,

Philip K. McKnelly
Director

2.0 **INTRODUCTION**

The division must identify the nature and status of park resources in order to recognize negative changes in their condition, and to then address those changes through management intervention. The implementation of a natural resources inventory and monitoring program will enable field staff and resource management personnel to develop resource occurrence checklists, resource distributions, and resource status rankings. Rare species and critical habitats can then be identified and monitoring programs initiated as needed.

These guidelines define the inventory and monitoring goals, as well as the roles and responsibilities of division personnel. They then present a standardized and methodical plan for collecting, managing, and analyzing natural resource inventory data. Procedures for identifying monitoring priorities and designing monitoring protocols are covered last.

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3.0 POLICY

An inventory and monitoring program will be established in all parks. This program will be a long term endeavor, and although implementation should begin immediately, progress towards the attainment of the policy goals may necessarily occur in an incremental but continuous manner.

3.1 Definitions

Natural resource inventory: a data collecting activity designed to gather baseline information on a natural resource (e.g., geology, soils, hydrology, air quality, vegetation community-types, plant and animal species, and park disturbance history).

Natural resource monitoring: a long-term repetition of a specific data collection protocol that, upon analysis, allows the detection of changes in the condition of a park resource or resources.

3.2 Inventory Goals

Each state park shall assemble an inventory of selected natural resources. Inventory programs will document the occurrence, location, and condition of physical elements, habitat-types, identify threatened, endangered, or special concern species; and identify priority physical elements, habitats, and biota for long-term monitoring.

3.3 Monitoring Goals

Hypothesis-based monitoring programs will be developed to detect threats to selected park resources. Monitoring programs will provide an information base to support management decisions, and may also serve to measure the effectiveness of management intervention efforts.

4.0 ROLES AND RESPONSIBILITIES

4.1 Superintendent of State Parks

The Superintendent of State Parks will be responsible for the administration of the Natural Resource Inventory and Monitoring Guidelines.

4.2 District Superintendents

District superintendents are expected to assist with the allocation of personnel and equipment from other parks to work on various inventory projects in their district.

4.3 Park Superintendents

Park superintendents are expected to:

- recognize the need for and importance of natural resource inventory and monitoring.
- be capable of identifying and prioritizing inventory and monitoring needs in their park.
- seek and accommodate assistance from the Resource Management Program (RMP), non-division scientists, interns, and volunteers as appropriate to conduct needed inventory projects.
- enable the participation of park staff in inventory and monitoring projects to the extent of their interests and capability.
- ensure that the Natural Resource Inventory Database (NRID) is properly maintained.

4.4 Resource Management Program

The RMP is expected to:

- assist the park superintendents in identifying and prioritizing inventory and monitoring needs.
- solicit, manage, and conduct inventory and monitoring projects which will help to address identified needs.
- assist park superintendents in reviewing inventory projects conducted by others to ensure scientific quality and system-wide consistency.
- establish system-wide consistency in data management and NRID format.

4.5 **Natural Heritage Program**

The NHP is expected to:

- participate in conducting inventories whenever possible and appropriate.
- input park occurrences of NHP-tracked elements into the NHP database.
- include park land to the greatest extent possible when conducting or supervising county, regional, or ecosystem-based inventories.
- share data from relevant inventories with park staff and RMP staff.

4.6 **District I & E Specialists**

District I & E specialists are expected to:

- participate in conducting inventories to the extent of their interest and capability.
- assist as appropriate in maintaining the NRID by documenting observations.
- assist park staff in identifying academic researchers, agency scientists, volunteers, and other non-division personnel to participate in inventory projects.

5.0 **BASELINE INVENTORY**

5.1 **Inventory Components**

A comprehensive baseline inventory should aspire to assemble data on as many of the following categories as possible:

A. Geology
- 1. Topographic maps
- 2. Geologic maps
  - a. bedrock and surficial geology
  - b. principal mineral composition of geologic units
- 3. County level soil maps
  - a. soils classification
  - b. pH

B. Water resources
- 1. Hydrography
  - a. map of surface water locations
  - b. map of wetland locations
  - c. map of groundwater recharge/discharge sites
- 2. Classification of all park streams
- 3. Location of closest water quality gaging stations
- 4. Water chemistry (of key bodies of water based on uniqueness, habitat value, threats)
  - a. pH
  - b. temperature
  - c. dissolved oxygen
  - d. conductivity
  - e. turbidity
  - f. pollutant concentration
  - g. flow
  - h. stage height

C. Air resources
- 1. Location of closest ambient air quality monitoring stations
- 2. Air quality
  - a. atmospheric gases present
    - I. Sulfur dioxide (SO_2)

ii. Ozone (O_3)

b. atmospheric particulates present

I. Sulfate anions (SO_4^{2-})

ii. Nitrates (NO_3^-)

iii. Hydrogen ions (H^+)

iv. Ammonium (NH_4^+)

v. Pesticides

vi. Trace metals (Na, Pb, etc.)

c. day time visibility

d. night sky brightness (limiting magnitude)

D. Climate

1. Location of closest weather station
2. Rainfall amount (daily, monthly)
3. Snowfall amount (w/ snow-water equivalents)
4. Maximum and minimum air temperature (daily, monthly)

E. Vegetation maps

1. Current community-level vegetation maps
2. Historical vegetation maps, if available
3. Plant community site descriptions.

F. Biological resources

1. Species lists of native and exotic species
   - a. mammals (bats, small/medium/large terrestrial and semi-aquatic spp.)
   - b. birds (passerine, raptors, waterbirds)
   - c. reptiles (lizards, snakes, turtles, crocodilians)
   - d. amphibians (frogs, toads, salamanders)
   - e. fish
   - f. invertebrates (mollusks, terrestrial and aquatic arthropods)
   - g. vascular plants
   - h. non-vascular plants (mosses, liverworts, hornworts, lichens)
2. Distribution data (for selected species)
3. Population estimates (for selected species)

G. Park disturbance history

1. Logging history
2. Cultivation history
3. Fire history

4. Flood history
5. Storm history (hurricanes, ice, etc.)
6. Disease/pest outbreaks

H. Surrounding landscape data set

1. Neighboring natural lands (location, distance from park, size, ownership)
2. Regional hydrology
3. Landscape use maps
4. Location of water pollution point sources
5. Location of air pollution point sources

I. Remote sensing data

1. Aerial photography
2. Satellite imagery

5.2 **Inventory Priorities**

Each state park should prioritize the focus of initial inventory efforts. The recommended highest priority elements are hydrology data, soils maps, vegetation community maps, and vertebrate and vascular plant inventories.

6.0 COMPILING EXISTING DATA

Each park should assemble a historical database consisting of a bibliographic record of the published and unpublished research involving park natural resources. The historical database should include all forms of natural resource data accumulated by the park, including maps, photographs, species checklists, survey reports, and specimen collections.

6.1 Potential Data Sources

Historical data sets and references to ongoing data collections may be assembled from a variety of sources.

6.1.1 Park Archives

The on-site archives of each park should be thoroughly examined. When possible, former superintendents or other park staff should be consulted with regard to their firsthand knowledge of the park's natural resources and past studies of them.

6.1.2 Research Scientists

Scientific Research and Collecting Permit files should be used to identify government or academic scientists who have conducted research within the park. If a report of their research results cannot be accounted for, these scientists should be contacted and asked for a report of their research activities within the park, particularly species lists and site locations.

6.1.3 Academic Resources

The libraries, herbaria, and specimen collections of major state universities and nearby colleges should be searched for park-related documents and specimens. If necessary, consult a staff librarian for assistance in an efficient search of a library's resources, including master's theses and doctoral dissertations. Specimen collection curators should be asked for assistance in searching a specimen collection.

6.1.4 Federal Resources

Federal agencies will possess useful information with respect to geophysical resources and federally listed species. Physical data may be obtained from USGS National Water Quality Assessment water quality/quantity stations, National Atmospheric Deposition

Program atmospheric monitoring stations, and the National Climate Data Center in Asheville, N.C. The U.S. Fish and Wildlife Service may possess useful data regarding federally threatened or endangered species.

6.1.5 State Resources

Physical data are available from the Division of Water Quality (DWQ), the N.C. Geological Survey, the Division of Land Resources, and the Center for Geographic Information and Analysis.

Biological data are available from multiple sources. The Natural Heritage Program (NHP) has compiled occurrence documentation and distribution maps for threatened, endangered, and special concern species throughout the state. The State Museum of Natural Sciences may have species occurrence information for certain parks, as well as specimens collected from parks. Wildlife Resources Commission (WRC) staff and Scientific Council biologists may be able to offer useful information for certain taxa and locations. A GIS-based map of terrestrial vertebrate distribution is being developed by the N.C. Gap Analysis Project, which is sponsored by the USGS Biological Resources Division and operates in conjunction with the NHP, the WRC, and the State Museum of Natural Sciences, under coordination of the N.C. Cooperative Fish and Wildlife Research Unit. The DWQ's Biological Assessment group monitors stream macroinvertebrates statewide. Additional plant databases are accessible from the N.C. Plant Conservation Program and the N.C. Vegetation Survey.

7.0 COLLECTING NEW DATA

In the absence of complete and current data sets, field surveys and recordings of day-to-day observations will be needed to compile accurate inventory lists.

7.1 Inventory Surveys

Field survey protocols vary considerably within and between taxa. The desired protocols for a specific taxa should be researched in order to learn the most efficient and suitable methods. Changes to the recommended protocols may be necessary to adapt to particular circumstances that develop on a site-by-site basis. Survey projects that are suggested by non-division investigators should be reviewed to ensure that they demonstrate a scientifically sound methodology.

7.1.1 Inventory Survey Report

A survey report should be completed in conjunction with an inventory survey. The precise protocol used in any inventory survey should be described in the survey report in sufficient detail that it may be replicated by future investigators. The survey report should indicate the names and titles of the investigators involved in the survey, and an overall opinion of the survey's effectiveness by the lead investigator.

A field report should also include a copy of the data sheets completed during the survey. Information collected on a data sheet should include the name of the investigator(s), the date of the survey, a description of recent climatic conditions, a record of the location (marked on a USGS 7.5 Minute Series topographic map), the survey area's natural community classification (following Schafale and Weakley's 1990, *Classification of the Natural Communities of North Carolina; Third Approximation*), a description of micro-habitats searched, a description of collection techniques, the duration of the survey effort, a species list with observation frequencies, and, optionally, measurements made of each specimen.

Appendix A provides a generic example of a data sheet format. Some inventory protocols require a specific data sheet format (e.g., N.C. Vegetation Survey, USDA Bird Count Census, etc.).

7.2 **Daily Observations**

Valuable observations of certain rare and/or secretive species are often the result of chance encounters. To keep the records of such day-to-day observations organized and easily accessible, it will be important to incorporate them into a park's Natural Resource Inventory Database (NRID). The FileMaker Pro software program necessary to run this database should be loaded onto at least one personal computer within each park office.

Entering an observation into the database will require noting the species observed and the date of the observation. Other important elements that should be recorded include: the number of individuals seen, the location of the siting, notable weather conditions, and unusual physical characteristics of the specimen. See Appendix B for a guide to using the NRID.

8.0 VOUCHER SPECIMENS

A voucher specimen is a plant or animal that is collected from a location, sacrificed, identified to species, and permanently stored in a specimen collection. The specimen then serves as a voucher or piece of documentary proof that substantiates claims of the species' site occurrence. In this way, voucher specimens offer credibility to the species list and distribution data of an inventory project in the face of scientific or legal challenges. For this reason, park voucher specimens could become an important issue when documenting the species diversity and distribution changes caused by environmental disturbances.

8.1 Collecting

For environmental, ethical, and storage considerations, the number of voucher specimens collected should be kept to the absolute minimum necessary to document the biological diversity of a park or particular park habitat. DOR (dead-on-road) specimens are ideal for voucher collection if the specimen is not too damaged. Many parks may already have a number of their species represented in academic or state museum collections, particularly in connection to thesis and dissertation studies. A specimen of an animal or plant species not known to be vouched for a park should be photographed (slide film - dated and with the observer's name) or collected if encountered during field surveys. Rare species should not be collected; voucher them via photographs. It is also advisable to document unusual species variants as future genetic research may recognize new species designations. Specimens with genetically based deformities (e.g., multi-limbed anurans) should be vouchered or in some other way documented for that species or location.

8.2 Storage

Most parks do not have the space to store physical specimen collections, nor the time and materials for their proper curation. It is generally advised that park staff seek an outside source to store and care for voucher specimens. The State Museum of Natural Sciences is the strongly preferred repository for voucher specimens collected from state parks. Photographic vouchers (slides) are convenient for storing at park facilities.

8.3 Preserving Voucher Data

Voucher specimens that are on hold to be transported to a collection facility should generally be maintained alive, or stored in a freezer if dead. If a curator suggests sacrifice and preservation at a park prior to transport, instructions should be requested.

9.0 RESEARCH/COLLECTING PERMITS

The collection, removal, or disturbance of park animals, plants, rocks, or minerals by non-division personnel requires a N.C. Division of Parks and Recreation Scientific Research and Collecting Permit. The collection of non-game animals by anyone requires a permit from the N.C. Wildlife Resources Commission. Depending upon the state or federal protection listing of the species targeted for study, permits from the N.C. Department of Agriculture Plant Conservation Program or the U.S. Fish and Wildlife Service may also be required.

For further information regarding N.C. Division of Parks and Recreation Scientific Research and Collecting Permit conditions and forms see: http://ils.unc.edu/parkproject/ncresmgt/permitinfo.html, or contact the appropriate park superintendent.

10.0 DATA MANAGEMENT

Each park will be expected to manage park inventory data sets following a standardized convention. This should prevent confusion in referencing data sets following a turnover in park staff.

10.1 Hard-copy Data

Hard-copy data sets (maps, field survey reports, photographs, scientific journal articles, etc.) should be organized in data files following the natural resource categories listed in Section 5.0, COMPONENTS OF A BASELINE INVENTORY. Duplicate copies should be placed in more than one category if appropriate (e.g., an aquatic inventory that covered both fish and aquatic mollusks should be copied and filed in both categories).

10.2 Computerized Data

The NRID has been designed to maintain data for the species and natural communities present within each park. This database offers a highly accessible, standardized format for organizing species and natural community occurrence data. Inventory data attained from all field surveys should be promptly assimilated into the NRID. A guide to using the NRID is detailed in Appendix B.

10.3 External Data Collections

It is not necessary, or sometimes even possible, to maintain a copy of all the data available for a particular subject (e.g., climate or air quality data being collected by other government agencies). In such cases the data collection should be referenced. A thorough reference to ongoing data collections by other agencies should include a bibliographic reference to the collecting agency, a summary of the time period spanned by the dataset (if applicable), and a note regarding the last date on which the data collection was referenced.

11.0 INVENTORY DATA ANALYSIS

Periodically, an analysis of a park's inventory data should be completed in order to reap the usefulness of its information and to justify its collection. The frequency of data analysis will have to depend upon individual rates of data collection.

Given quality species survey reports and/or an accumulation of well documented daily observations, a park should be able to gradually meet the following objectives:

- develop current, well documented species checklists
- determine species/habitat associations
- develop a map of known and predicted site occurrences for each species
- estimate abundances of species
- identify populations and sites of special concern
- identify top priorities for monitoring

12.0 **ESTABLISHING A MONITORING PROGRAM**

Quality monitoring programs provide timely and credible evaluations of a resource's status, thereby providing a coherent base for management actions. Monitoring programs will vary in their designs as they address different situations. The implementation and analysis of an unbiased and statistically powerful monitoring program can be very complicated and costly of time. Therefore, great care must be taken in designing a monitoring program. Park monitoring programs are expected to develop under the combined effort of RMP personnel, non-division scientists, park superintendents, and park rangers.

12.1 **Identifying Monitoring Priorities**

Individual monitoring programs can be demanding of resources, and require a long-term (10+ years) commitment. It is therefore unlikely that any park will be able to monitor all of the physical resources, taxa, or natural community types contained therein. Park superintendents and rangers will need to assist RMP personnel in prioritizing which natural resources merit management attention. The following questions should be considered when identifying candidates for environmental monitoring:

- Which resource(s) are exposed to the most stress (negative environmental influences)?

- Which resource(s) are the most sensitive to stress? (possible "bioindicators")

- What is/are the stressor(s) and are they measurable in concentration or abundance?

- Which resource(s) are key elements in the ecological stability of the natural communities present?

- For which resource(s) does the park serve as a significant state, regional, or federal refuge?

  -- endemic species or habitats

  -- species of threatened, endangered, or special concern legal status

- What resource(s) could the park monitor that would contribute to larger monitoring programs run by other agencies? (The added spatial replication allows for stronger interpretation of results and therefore faster identification of negative trends)

- Which resource(s) are the most significant to the park's identity, based on charisma/public interest?

- Which resource(s) are practical to monitor by tested methodologies?

- Which resource(s) could be monitored by low impact methods?

- Which resource(s) could be monitored without prohibitive costs?

- Which resource(s) will require scientific specialists to monitor, and are those scientific specialists obtainable?

- Which resource(s) could, if the need was indicated by monitoring, actually be managed for recovery given a park's resource limitations?

12.1.1 **Biological Indicators**

Biological entities that show an observable early sensitivity to environmental change are termed "biological indicators" or "bioindicators". Focusing on biological indicators improves the ability of monitoring programs to detect negative environmental influences before they cause considerable effects that may be difficult to mitigate.

12.1.1.1 **Biological indicator characteristics**

Biological indicators are taxa which possess the following characters:

- Sensitivity of a measurable attribute (e.g., size, fecundity) to environmental changes that affect the larger ecosystem as a whole.

- A low natural variability in the attribute to be monitored, allowing significant variances to be more easily detected.

- A wide ranging distribution, and high natural abundance.

12.1.1.2 **Biological indicator examples**

- Lichen populations as an indicator of air quality.

- Stream macroinvertebrate abundance and species diversity as indicators of water quality.

12.2 Designing a Monitoring Protocol

Scientific credibility in declaring a negative resource trend to be genuine and significant relies upon a monitoring protocol that is properly designed. A monitoring protocol should be carefully constructed and critically evaluated before it is implemented. RMP personnel and non-division scientists will be expected to collaborate to design monitoring protocols that meet the following minimum requirements.

12.2.1 Monitoring Hypothesis

Every monitoring protocol must be based on a monitoring hypothesis. A monitoring hypothesis should be a statement regarding the status of a monitored resource, whose acceptance or rejection stimulates management actions. The monitoring hypothesis should be explicitly related to natural resource management issues important to the park.

*See Appendix C for further details of monitoring hypotheses.

12.2.2 Sampling Methodology

Monitoring protocols must collect data repeatedly using consistent, practical, and accepted methodologies.

(1) The sampling methodology must be fully documented to enable exact replication by different parties at future dates.

(2) The sampling methodology must use conventional, affordable equipment, and be realistic in the time investment required.

(3) In order to allow strong statistical analysis of the monitoring hypothesis, the sampling methodology must be suitably replicated, and must produce unbiased results with low variability. A monitoring protocol will therefore likely require a period of research and development. Whenever possible, well-established regional or national protocols

(e.g., USDA Bird Point Count Census, USGS North

American Amphibian Monitoring Program, the N.C. Vegetation Survey, NCDWQ's Biological Assessment program) should be used or adapted.

*See Appendix C for further details of the design requirements of a monitoring protocol.

13.0 PERSONNEL

In order to make progress towards policy objectives, the division will undoubtedly need to rely on a variety of outside sources. Other DENR units and staff, academic researchers (faculty, graduate students, undergraduate field courses), interns, contract field technicians, and community volunteers all have the potential to assist in inventory surveys and monitoring projects.

The level of background expertise needed to properly execute a field survey will depend upon the target taxa and the survey methodology. In many situations, inexperienced personnel can still be useful if blended with a core group of experienced scientists.

13.1 Requesting Assistance

The division should attempt to recruit assistance from outside sources.

13.1.1 Department of Environment and Natural Resources (DENR) Personnel

If made aware of the opportunity and need, some DENR personnel (field scientists and others) may agree to assist in an inventory project. A number of DENR divisions have conducted resource inventory and monitoring projects throughout the state, and may be interested in studying state park areas if they have not already (e.g., DWQ Biological Assessment Program, WRC Nongame Program Projects).

The State Museum of Natural Sciences scientists conduct a great deal of field research. These scientists should be made aware of cooperative research opportunities available within the state parks system. The interest of the various museum collections in statewide species distribution data would be well-served by state park inventory projects.

13.1.2 Academic Institutions

The Biology, Environmental Sciences, Forestry, Wildlife and Fisheries, and Entomology departments of University of North Carolina system universities and other nearby colleges may contain faculty and students interested in inventory and monitoring projects. Academic researchers who have conducted studies within the park system in the past should be re-contacted. Other potentially interested faculty could be identified by screening the various department information offered by university internet resources.

13.1.3 **Community Volunteers**

Some parks may have the potential to recruit volunteers and summer interns from the local community.

14.0 SAFETY

Since inventory and monitoring studies frequently require work in physically demanding environments, the safety issues of physical fitness and adequate training must be addressed prior to the initiation of survey activities.

14.1 Physical Fitness

Field surveys may require long-distance hiking over rough terrain, manually transporting field equipment, and long working hours. All participants in a field survey should possess adequate stamina and strength to effectively contribute without being a threat to themselves or a liability to others.

14.2 Special Training

Field and laboratory activities often involve particular skills and safety considerations.

14.2.1 Animal/Plant Exposure

All field workers that will potentially be exposed to wild animals must be educated to the appropriate safety issues and techniques.

- Mammals: Investigators should be extremely cautious and alert when handling mammals, as most species can bite and scratch significantly. Any persons directly handling bats should be immunized against rabies and observe proper post-bite procedures if necessary (wash, sterilize, receive post-exposure vaccination). The need for air filtering equipment as precaution against histoplasmosis infection when surveying bat roosts should be evaluated. Investigators handling rodents should take all necessary precautions against hantavirus infection, including protective clothing, gloves, goggles, and air-purifying equipment. Persons handling larger mammals should wear gloves and take the necessary rabies precautions.

- Reptiles: Snakes, freshwater turtles, and alligators can deliver damaging bites or scratches if handled incorrectly. Venomous snakes should be avoided by all but experienced herpetologists, but at least one member of a field survey team should be familiar with snake-bite first aid procedures. Reptiles (especially turtles) may transmit salmonella bacteria, and therefore one’s hands should be sanitized after exposure.

- Invertebrates: Hymenoptera, hemiptera, and large arachnids can each penetrate human skin with a sting, stylet puncture, or bite. Persons with bee allergies must carry allergy medication at all times in the field. Black Widow and Brown Recluse spiders are dangerously venomous, and their bites should receive medical attention. Terrestrial mollusks should be viewed as potential vectors of harmful bacteria, and therefore one's hands should be sanitized after exposure.

- Plants: Persons with serious sensitivity should take care to avoid poison ivy, poison oak, and poison sumac. All persons should wash themselves and their field clothes after operating in poison ivy/oak/sumac areas to remove the toxic oils.

14.2.2 **Survey Skills**

A particular survey may require a demonstrable or certified skill in caving, canoeing, electro-shocking, orienteering, rock climbing, SCUBA diving, or operating a motor vehicle (land or water). These activities should not be attempted by non-proficient personnel.

14.2.3 **Chemical Exposure**

Persons who will be exposed to anesthetizing, euthanizing, fixing, or preserving chemicals must be trained in their safe usage and have access to safety gear. Persons working in a laboratory should be familiar with all lab safety protocols.

15.0 EQUIPMENT

Each inventory protocol typically has its own set of required equipment. Outside investigators may supply the necessary equipment for certain inventory and monitoring projects. Necessary equipment that cannot be acquired from other parks or from non-park related sources will need to be purchased.

15.1 Equipment Inventory

An inventory of all natural resource survey equipment, including type, quantity, condition and location should be documented by each park. Up-to-date equipment inventories should ease intra-park equipment loaning attempts.

DATA SHEET

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Name:	Date:	Taxa/Habitat surveyed:

Geographic Characterization

Geographic division: coastal/piedmont/mountains	Specific locality:
Elevation:	Latitude and longitude:

Climate

24 hr. precip. total:	Month precip. total:
Observation period ave. temp. (air or water):	Month ave. temp.:
% cloud cover:	Wind conditions:

Habitat (terrestrial or aquatic)

Vegetation community:	Substrate type:	Microhabitats present:
General topography:	Disturbances:	Notes:

Specimen Collection

Technique:	Start time: End time:
Equipment:	Notes:

FIELD DATA SHEET

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No.	Species	Location	Substrate	Size	Sex/Maturity	Time
1						
2						
3						
4						
5						
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7						
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10						
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NATURAL RESOURCE INVENTORY DATABASE

The NRID is now web based at [contact Tom Howard for this information and for the login code]. This should improve the speed of operation for park field staff. The NRID is an evolving tool, and changes may occur from time to time. Fortunately, the database is almost entirely self-explanatory. Operating instructions are given at the NRID website, and these will be updated to keep up with any modifications to the database. However, if you have questions regarding the NRID, please feel free to ask for assistance.

Tom Howard, South District I & E Specialist: the contact for any technical questions regarding the NRID website (e.g., adding an un-listed species, reporting a malfunction, trouble adding photos, etc.).
Phone #: (919)846-9991
Email: Tom.Howard@ncmail.net

Seth Lambiase, Resource Management Program biologist: the contact for questions regarding taxonomy, data sources, data quality, and data classification.
Phone #: (919)715-8693
Email: Seth.Lambiase@ncmail.net

MONITORING PROGRAMS

Monitoring Objectives

A monitoring program must be designed based on a clear objective. A properly defined monitoring objective has a target species/population/community, a character trait to be measured, a specific effect (e.g., increase, decrease), a selected location, and a time-frame. A monitoring objective should fall into one of two categories:

A. Monitoring for Change Over Time

The objective is to monitor the changes of a targeted parameter over a set time period. A data sampling protocol must be carefully designed to allow for the accurate identification of any trends or the lack thereof.

B. Monitoring a Threshold Level

The objective is to monitor for a parameter's increase or decrease to an acceptable or unacceptable threshold condition. A data sampling protocol must be carefully designed to allow for confident estimations of the parameter's condition.

Monitoring Plan Design

The monitoring plan is the strategy by which the monitoring objectives will be suitably met. The standard and most effective strategy is to use a quantitative study to provide information regarding the status of a resource in question. A quantitative approach to resource monitoring uses sampling of a whole population to estimate mean values for comparison. A quantitative study allows one to accurately identify both the precision level of estimated means, and the probability of a significant difference between compared means. The statistically represented conclusions of a quantitative monitoring study offer a known measure of confidence to any resultant management decisions.

A. Monitoring Hypothesis

When monitoring for changes over time, a hypothesis must be defined and then tested based on a statistical analysis of sampled data. The hypothesis that is tested is called a "null hypothesis". A null hypothesis would state that *no change has occurred in a monitored parameter over time.* A statistical analysis of the data sampled by a monitoring program would offer a rejection or a failure of rejection of the null hypothesis with a known degree of certainty.

A null hypothesis is also necessary when monitoring a threshold level. A null hypothesis would state that *the monitored parameter has not increased and/or decreased beyond a certain value.* A statistical analysis of the data sampled by a monitoring program would offer a rejection or a failure of rejection of the null hypothesis with a known degree of certainty.

**It is very important that a monitoring program's null hypothesis be stated or regarded by management in such a way that its rejection or its failure to be rejected would offer clear direction to resource management actions/decisions.

B. Data Sampling

Data sampling refers to the collection of the desired parameter measurements in the field. A careful consideration of data sampling requirements is critical to the ability to statistically evaluate a null hypothesis.

1. Randomness

As a rule, randomness in sample selection reduces sampling bias. Bias is a systematic error in data collection that prejudices the outcome of a study.

When the goal of a monitoring program is to estimate trends in a selected resource for an entire park, sample units should be randomly selected throughout the whole of the park area. There may be a temptation to select the general area of sample units in order to accommodate the accessibility advantages offered by trail and road systems. That should be recognized as a non-random selection and avoided as much as possible. Parks that are attempting habitat-specific monitoring programs (e.g., of prescription burned areas, amphibian breeding pools) obviously must select specific locales for sampling, but then sample units within those areas should be randomly selected.

2. Sample Size

Sample size is the number of units to be sampled from each locality, population, time period, etc. A greater number of sample units (high replication) generally correlates with a lower variability in measured sample mean values (this is also referred to as a low standard error). Powerful statistical tests of whether or not average sample means (e.g., size of population X in 1995 vs. 1999) are significantly different requires low standard errors for each mean. However, logistical implications and other restrictions on very large sample sizes means that they are not always possible. A statistical power analysis should be used to predict a minimum sample size needed for a study (see 4. Statistical Power).

** It is critically important that sample units be independent of each other in terms of the measured parameter if they are to be counted as separate replicates. "Pseudoreplication", the over-estimation of sample size because of a failure to recognize a lack of sample independence, is a common and debilitating error in ecological research. Pseudoreplication is a complicated subject and statistical experts and/or texts should be consulted if necessary (Hurlbert 1984; Sokal and Rohlf 1995).

3. Sampling Frequency

Inventory-style surveys may perhaps permit very crude estimates of resource fluctuations when replicated on multi-year cycles. And, if conducted by an investigator that is highly knowledgeable and familiar with a particular resource, such a detection program might allow tolerably logical and timely management decisions. However, it should be expected that infrequent observations will much more often be insensitive to all but the most obvious changes in resource status.

Sample mean values derived from small sample sizes tend to be inherently high in variability. High sample mean variability can mask non-random mean changes (trends) so that they cannot be identified with appropriate statistical confidence. Therefore, robust monitoring programs require a certain frequency of sampling to properly test a null hypothesis. A statistical power analysis should be used to predict a minimum sampling frequency needed for a study (see below).

4. <u>Statistical Power</u>

The statistical power of a monitoring program refers to the sensitivity of the data analysis to detecting a parameter change when such a change has indeed occurred. Clearly, monitoring programs must have high statistical power in order to diminish the chances of missing significant environmental problems. In order to construct a monitoring program of functional sensitivity and scientific credibility, follow these points taken from Evans (1997), Elzinga et. al. (1998), and Eagle (1998). Devise and record the complete sampling strategy and statistical analysis protocol before beginning a monitoring project.

(1.) When testing a null hypothesis, consider the relative costs of a false positive result, (claiming a problem when there is none), versus a false negative result, (claiming there is no problem when one does exist). For a monitoring program, the consequences of missing a true population decline are generally considered more undesirable than the occasional false alarm.

Choose probability levels for and . A common policy for monitoring purposes is to set = = 0.1 or 10%. With a = 0.1, a monitoring program will have the power to detect 90% or (1 -) of all real population trends, and with = 0.1, there would only be a 10% chance of falsely detecting a change.

It is important to note that and are correlated values. Power (1-) is a function of the number of sample units, the variability of the sample means, the detectable rate of change (effect size), and . Both and cannot be minimized to eliminate the possibility of making any error unless the sample size and/or detectable rate of change are greatly increased and the data variability greatly decreased -- requirements that are impractical or impossible.

(2) Estimate the variability of the sampling data to be measured by the monitoring project (measured in coefficients of variance, CV), either using results from past research (Gibbs 1998) or by conducting a pilot study.

(3) Choose a desired effect size, based on management objectives. The effect size determines how large of a change in mean values you can detect over time. Note that 2%, 3%, and 5% yearly changes will grow into net 19%, 26%, and 40% changes over 10 years. Large effect sizes are the easiest to detect, but are also the

least preventative of environmental damages.

(4) Employ a power analysis (see Gibbs 1995; Thomas 1997). Use it to calculate the minimum effect size possible given the desired and values and estimated coefficient of variance (CV) of the study parameter. Or, conversely, determine the minimum data variability (CV) necessary to accommodate a desired effect size and and values. For a chosen effect size, and values can be increased to reduce data variability restrictions, but remember at what cost to statistical power.

(5) Consider ways of reducing the variability of the sample data measurements (CV) in order to meet the demands of the chosen and values and effect size. Lowering sample data variability can be accomplished by following a well-tested, unbiased protocol, by using a random sampling pattern, and by keeping permanent sample sites. However, some degree of data variability will be natural even without methodological error.

Given good methodology, the most effective means of reducing sample data variability is to increase the data sample size (i.e., more sample units, more frequent sampling). A statistical power analysis (refer to Gibbs 1995; Thomas 1997) should be used to determine the most feasible combination of sample unit number, sampling frequency, and length of sampling period, in order to reduce data variability values to the necessary level.

5. Sample Unit Permanency

Once randomly established, sampling units should be made permanent if possible. Permanent sites need to be well marked in the field, and recorded on maps so that they are not lost during the duration of the monitoring program. This is more costly and time consuming than re-randomly selecting all new sites for new measurements. However, permanent units tend to significantly lower sample variability over time in comparison to non-permanent sample units, especially if there is a strong correlation in the parameter values of a unit over time.

C. Qualitative Approach

A qualitative study does not measure or count a parameter in a precise numerical manner, and is therefore often less intensive. The conclusions of qualitative studies are particularly susceptible to error from observer variability, and one cannot explicitly express their probability of accuracy. Quantitative studies are superior to qualitative studies and should be favored whenever possible. However, sometimes it is not possible to quantitatively monitor a particular resource due to a lack of time, funding, or necessary ecological knowledge. If an issue is important a qualitative approach to monitoring may still be a worthy undertaking. Observers can make estimated or ranked assessments of species abundance or habitat condition, or time-series point-photography can be used to evaluate change at a site.

Monitoring Program Review

A monitoring program should set a schedule for periodically evaluating collected data before the final termination of the project. Intermittent scrutiny of monitoring data should enable the detection of errors in plan design, execution, or data recording before too much time and effort has been wasted.

At the end of the monitoring time-period, the sample data should be carefully analyzed. If the program was well planned and executed, the interpreted results should advise a definite management action.

A. Pilot Period

A pilot period after the start of the monitoring program should be used to evaluate whether the monitoring plan is on track to meet the monitoring objectives. Double-check the original plan: What is the level of sampling variability? Is it feasible to have the detectable effect size and statistical power set at the values initially desired? Can the detectable effect size be set lower or the power raised? Is the field protocol practical and affordable? Are all assumptions still valid? Are the results interpretable? Is there inordinate difficulty in finding an appropriate statistical test? Overall, is the monitoring plan acceptable as is or should it be changed?

B. Statistical Analysis

Quantitative, sampling-based monitoring projects need to be evaluated by statistical software. A variety of software packages are available, including SYSTAT, SAS, JMP, and EXCEL. Proper statistical analysis is complicated, involving tests of data normality and homogeneity of variance, applying data transformations, and selecting the appropriate statistical test. Statistical experts and/or texts should be consulted as necessary (see Sokal and Rohlf 1995). A properly chosen and executed statistical test will either reject or not-reject the null hypothesis, thereby fulfilling the purpose of the monitoring program.

If at the end of the data testing a monitoring study does not reject the null hypothesis, a post-hoc power analysis should be performed. The post-hoc power test will determine the probability that the study could have failed to detect a real change. This will then indicate how confidently the results should be viewed. The power level (1-) should be close to the value targeted in the experimental design stage if, during the study, the sample data variability and sample unit number remained close to the planned/expected values.

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